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Group No.:

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Attached please find the certified copy of the foreign application from which priority is claimed for this case:

Country	**: Finland**
Application Number	**: 20000569**
Filing Date	**: 10 March 2000**

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Helsinki 20.10.2000

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JAN 16 2001
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E T U O I K E U S T O D I S T U S
P R I O R I T Y   D O C U M E N T

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Hakija Applicant	**Nokia Mobile Phones Ltd** **Espoo**
Patenttihakemus nro Patent application no	**20000569**
Tekemispäivä Filing date	**10.03.2000**
Kansainvälinen luokka International class	**H04R**

Keksinnön nimitys
Title of invention

"Microphone structure"
(Mikrofonirakenne)

Täten todistetaan, että oheiset asiakirjat ovat tarkkoja jäljennöksiä patentti- ja rekisterihallitukselle alkuaan annetuista selityksestä, patenttivaatimuksista, tiivistelmästä ja piirustuksista.

This is to certify that the annexed documents are true copies of the description, claims, abstract and drawings originally filed with the Finnish Patent Office.

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Microphone structure –
Mikrofonirakenne –
Mikrofonstruktur

The invention relates in general to microphones. In particular the invention relates to microphones in cellular phones and their accessories.

There is a general need to protect microphones against radio frequency (RF) disturbances for ensuring the proper performance of the microphones. Microphones of cellular phones or cellular phone accessory should furthermore be very immune to RF disturbances at those frequencies which the cellular system uses. Consider for example a headset accessory of a cellular phone. It has a small earpiece which is connected to the cellular phone with a wire and the microphone of the headset is mounted on the wire at a suitable distance from the earpiece so that it can pick up the voice of the user. The user may carry the cellular phone in a pocket during a phone call. If the user carries the cellular phone in a breast pocket of a shirt or a jacket, the microphone of a headset is very near the RF transmitter of the cellular phone. If the microphone is not adequately protected, the quality of speech may deteriorate. Furthermore, there is need to protect microphones against electro-static discharge (ESD).

Electret microphones are one type of microphones that are used in cellular phones and accessories. An electret microphone contains a preamplifier, typically a field effect transistor (FET), and voice is converted to electrical signal by changes in capacitance. Changes in the air pressure cause changes to the capacitance between a conductive plate and a conductive foil. The conductive plate, the conductive foil, FET and other microphone components, which are typically capacitors, are typically placed in side a microphone capsule. This capsule has typically two output pins using which it is connected to other circuitry.

Electret microphones are conventionally protected against RF disturbances and ESD in various ways. The aim is to obtain ESD protection and protection against RF disturbances in a wide frequency range. One solution to obtain RF protection is to add small capacitors, which are tuned to the transmission frequencies of a cellular phone, inside the microphone capsule. The problems here are that the layout of the microphone components on a circuit board has to be done very carefully and the RF protection works only for narrow frequency bandwidths. Furthermore, changes in

the capacitance values of the capacitors, even changes within manufacture tolerances, may cause the RF protection to tune out from the desired frequency bands.

The ESD protection is usually carried out by placing an ESD protector, which may be for example a zener diode or a varistor, on the circuit board near the microphone capsule. The problem here is that the ESD protector has some internal capacitance, and this capacitance couples with the capacitance of the microphone (resonance of two or more parallel capacitors). This may lead to RF protection failures at some frequencies. It is possible to add a resistor to ease the resonances caused by the ESD protector and the capasitors inside the microphone, but such a resistor should be very large to sustain an ESD pulse. Small surface mounted resistors change their resistance and typically eventually fail in ESD tests. Adding a resistor between the ESD protector and the microphone may cause the microphone more susceptible to ESD. It is possible to use ferrite beads instead of resistors, but they are more expensive than resistors and do not solve the resonance problem. They may even make the RF protection worse.

In conventional designs, there may be up to 10 additional components whose purpose is to protect the microphone from ESD and RF disturbances. The immunity to both ESD and RF disturbances is difficult to achieve, and even with 10 extra components the protection may still be inadequate.

The object of the invention is to present a microphone structure which is compact, relatively immune to radio frequency disturbances and protected against electrostatic discharge.

The aim of the invention is achieved by placing the electro-static discharge protector inside the microphone capsule, where it acts as part of a low-pass filter which protects the microphone from radio frequency disturbances.

A microphone structure according to the invention comprises within a microphone capsule
- means for converting changes in air pressure to an electrical signal,
- amplifier for amplifying the electric signal and having two outputs, each output coupled to an output of the microphone capsule, and
- a capacitor connected between the outputs of the amplifier, and it is characterized in that it further comprises an electro-static discharge protector connected between

the microphone capsule outputs and, within the microphone capsule, a resistor coupled in series with the capacitor

A microphone structure according to the invention comprises the typical components, which are needed to convert changes in air pressure to electrical signal. These components usually comprise a conducting foil and a conducting plate, and change in the air pressure cause changes to the capacitance between the foil and the plate. A (pre)amplifier, for example a field effect transistor, and a capacitor connected between the outputs of the amplifier are also typical components is a microphone structure. Verb connect refers here to a galvanic connection and verb couple refers to a connection which may pass via other components.

A microphone according to the invention is characterized in that it comprises an electro-static protector, which is connected between the outputs (or pins) of the microphone capsule, and inside the microphone capsule a resistor connected in series with the capacitor. The ESD protector may be either just outside the microphone capsule or within the microphone capsule. Preferable the resistor and the ESD protector are on the same circuit board as the amplifier and other microphone components. This makes the signal loops, which may be susceptible to RF disturbances, smaller. The capacitor, resistor in series with the capacitor and ESD protector in parallel with the capacitor form a low-pass filter, when the ESD protector and the resistance of the resistor are properly selected and the components are properly coupled to each other. The resistor within the microphone capsule also increases the impedance of disturbing signals.

The main advantage of the invention is that when the ESD protector is placed just next to the microphone capsule or within the microphone capsule, the ESD protector works both as an ESD protector and as a part of a low-pass filter. The ESD protector in a microphone structure according to the invention is typically a varistor, which is a component whose resistance depends on the applied voltage. In the microphone capsule there typically is room for a varistor and for a resistor. When the filtering of disturbances is performed within the microphone capsule, the microphone capsule, which may be conductive, may act as a Faraday case and further enhance the performance of the microphone.

A further advantage of the invention is that the internal capacitance of the ESD protector, which in the conventional microphone ESD protection is usually a problem because it changes the designed RF protection of a microphone, enhances the low-

pass filtering in a microphone according to the invention at low frequencies. A further advantage is that the microphone according to the invention may work as an ESD protector for other components in the device.

A microphone according to the invention has typically several components less than a conventional microphone with external low-pass filtering and ESD protection circuitry. In addition, the components (for example, a varistor and a resistor) can be added to the same circuit board as the other microphone components. This makes the microphone easy to manufacture and also reduces the cost of the microphone. The microphone audio performance, in other words the quality of speech, is also better for a microphone according to the invention than for a conventional microphone. This may be the case even when a conventional microphone is equipped with external low-pass filtering and ESD protection circuitry.

The invention will now be described more in detail with reference to the preferred embodiments by the way of example and to the accompanying drawings where

Figure 1 shows schematic circuit diagrams of a first conventional microphone and a microphone according to a first preferred embodiment of the invention,

Figure 2 shows schematic circuit diagrams of a second conventional microphone and a microphone according to a second preferred embodiment of the invention,

Figure 3 shows schematic circuit diagrams of a third conventional microphone and a third microphone according to the invention,

Figure 4 shows a schematic drawing of a first layout of the components of the microphone according to the first preferred embodiment of the invention on a circuit board,

Figure 5 shows a schematic drawing of a second layout of the components of the microphone according to the first preferred embodiment of the invention on a circuit board,

Figure 6 illustrates a direct RF injection set-up for testing the immunity of microphones to RF disturbances,

Figure 7 presents the indicated disturbance as a function of RF frequency for the first conventional microphone and the microphone according to the first preferred embodiment of the invention,

Figure 8 presents the indicated disturbance as a function of RF frequency for the second conventional microphone and the microphone according to the second preferred embodiment of the invention,

Figure 9 presents the indicated disturbance as a function of RF frequency for the third conventional microphone and the microphone according to the third preferred embodiment of the invention,

Figure 10 presents the measured disturbance as a function of RF frequency (150 kHz – 80 MHz) for a conventional headset,

Figure 11 presents the measured disturbance as a function of RF frequency (150 kHz – 80 MHz) for a headset with conventional filtering and ESD protection components and having a microphone according to the invention,

Figure 12 presents the measured disturbance as a function of RF frequency (150 kHz – 80 MHz) for a headset without conventional filtering and ESD protection components and having a microphone according to the invention,

Figure 13 presents the measured disturbance as a function of RF frequency (80 MHz – 1 GHz) for a conventional headset, and

Figure 14 presents the measured disturbance as a function of RF frequency (80 MHz – 1 GHz) for headset without conventional filtering and ESD protection components and having a microphone according to the invention.

Figure 1 shows on the left side an example of the circuit diagram of a conventional microphone. This first conventional microphone comprises inside the microphone capsule (presented with a circle in Figure 1) a conducting foil and a conducting plate, and a field effect transistor (FET) T1 connected to these. It further comprises a capacitor C2 connected between the pins of the FET, and the capacitance of C2 is typically 1 pF – 5 nF. The ESD protector and RF filtering components are in conventional microphones outside the microphone capsule, so they are not presented in

Figure 1. On the right side of Figure 1 there is a corresponding microphone according to a first preferred embodiment of the invention. It comprises in the microphone capsule an ESD protector (a varistor) R2, which is connected between the pins of the microphone capsule (i.e. in parallel with the capacitor C2) and a resistor R1, which is connected in series with the capacitor C1. The varistor R2 typically has a capacitance of 10 pF – 10 nF and a clamping voltage of 2 V – 20 V. The resistor R1 typically has the resistance of 1 Ω – 10 kΩ. This resistor R1 may alternatively be a coil or a ferrite bead.

As can be seen in Figure 1, it is quite simple to change the design of a conventional microphone to that of a microphone according to the invention. This is one of the advantages of the invention.

Figure 2 presents a second conventional microphone on the left side of the figure. In addition to the components present in the first conventional microphone, this second conventional microphone comprises a resistor R1 in series with the capacitor C1. On the right side of Figure 2 there is a circuit diagram of a corresponding microphone according to a second preferred embodiment of the invention. This microphone according to the invention comprises an ESD protector R2 within the microphone capsule. The values of the resistances and capacitances of the components are at the same ranges as those of the components of the microphone according to the first preferred embodiment of the invention.

Figure 3 presents a circuit diagram of a third conventional microphone on the left side of the figure. This conventional microphone comprises two capacitors C1 and C2 in parallel. A circuit diagram of a third microphone according to the invention is presented on the right side of Figure 3. It comprises, in addition to the components which are common with the third conventional microphone, a resistor R1 in series with the capacitors C1 and C2 and a varistor R2 in parallel with the capacitors and connected between the pins of the microphone capsule.

Figures 4 and 5 present two examples of how to place the components of the microphone according to the first preferred embodiment of the invention on the circuit board of the microphone capsule. The conductive foil and the conductive plate are not shown in Figures 4 and 5. The components in Figures 4 and 5 have the following reference markings: FET indicates the FET T1, CAP indicates the capacitor C2, RES indicates the resistor R1 and VAR indicates the varistor R2. The dashed area represents the conducting area on one side of, for example, a double sided circuit

board. The dark dots are lead-throughs, which connect the conducting areas on the opposite sides of the circuit board. The larger dashed area represents the ground level, and as can be seen in Figures 4 and 5 the ground level preferably surrounds the circuitry. Furthermore, the ground level is connected to the ground level on the opposite side of the circuit board using many lead-throughs. This way the impedance of the connection is small (signal is not reflected) and the ground level potential is the same throughout the ground level area. Both these features enhance the performance of the circuitry and protect the circuitry from RF disturbances. Near the center of the circuitry, the conducting area corresponding to the positive voltage is connected to the conducting area on the opposite side of the circuit board only via one lead-through.

One output of the FET is connected to the surrounding ground level, and the other ouput of the FET is coupled via an intermediate conductive area and the resistor RES to the positive voltage. The capacitor CAP is connected between the FET pins, and the varistor VAR connects the ground level and the positive voltage. The components are thus connected as specified by the circuit diagram on the right side of Figure 1. The difference with the component layouts presented in Figures 4 and 5 is the position of the resistor RES. Because the microphone circuitry according to the invention is not sensitive to the position of the components in the circuit board, the components can be placed quite freely on the board. Figures 4 and 5 also show that there typically is room on the microphone circuit board to place the ESD protector and a possibly additional resistor. In general, the component may either have connectors (conducting areas in the bottom surface of the components) or pins. Figures 4 and 5 present layout of components having connectors. The type of components (pins or connectors) may affect the layout of components on the circuit board.

Microphones are usually tested to find out their immunity to the RF disturbances. Figure 6 presents a schematic diagram of a set-up using which the immunity of microphones to RF disturbances can be tested. In this test, a RF signal of a certain frequency is amplitude modulated with a 1 kHz signal, which represents an audio signal. The RF generator in Figure 6 generates the RF signal (frequency range 150 kHz – 2.4 GHz) and the 1 kHz signal is modulated to this signal. The modulated RF signal is then conducted to the tested component via the Biastee block. The Biastee block is also used to provide a bias current to the amplifier in the microphone. The tested microphone or component having a microphone can filter some or all of the modulated RF signal. The part of the signal it cannot filter reaches the amplifier of the microphone and the amplifier detects the 1 kHz signal. The signal which the

amplifier detects and amplifies is obtainable via the Biastee block. The signal is low-pass filtered to prevent RF signal to enter the Audio Amplifier, and the result of the Audio Amplifier is analyzed with the Audio Analyzer. Basically it is compared to a constant calibration signal. This testing method allows the detection of how a microphone reacts to an audio signal (i.e. the 1 kHz test signal) modulated on an RF signal. It thus gives quite good estimation of the performance of a microphone in real usage situation, and reveals how easily a microphone reacts – in addition to the changes in the air pressure – to audio signal modulated to a disturbing RF signal.

Figure 7 presents the indicated disturbance as a function of the RF frequency for the first conventional microphone and for the microphone according to the first preferred embodiment of the invention. The test set-up is the one presented in Figure 6. The tested microphones have the following components: the capacitance of the capacitor C2 is 10 pF, the resistance of resistor R1 is 47 Ω, and the varistor R2 is a 5.6V varistor having an internal capacitance of 360 pF. The indicated disturbance of the microphone according to the invention is the lower curve in Figure 7. As can be seen, the microphone according to the invention is less sensitive to RF disturbances than the conventional microphone.

Similar results are presented in Figure 8 for the second conventional microphone and for the microphone according to the second preferred embodiment of the invention. The tested microphones have the following components: the capacitance of the capacitor C1 is 10 pF, the resistance of resistor R1 is 100 Ω, and the varistor R2 is a 5.6V varistor having an internal capacitance of 1 nF. Again, indicated disturbance of the microphone according to the invention is the lower curve.

Figure 9 presents the indicated disturbance as a function of the RF frequency for the third conventional microphone and for the third microphone according to the invention. The values of the components are the following: the capacitance of the capacitor C1 is 10 pF, the capacitance of the capacitor C2 is 33 pF, the resistance of resistor R1 is 47 Ω, and the varistor R2 is a 5.6V varistor having an internal capacitance of 360 pF. The lower curve in Figure 9 is the indicated disturbance of the microphone according to the invention. The third microphone according to the invention is thus less sensitive to disturbances than the third conventional microphone.

The difference between the microphone according to the first preferred embodiment of the invention and the third microphone according to the invention is that the latter has two capacitors in parallel within the microphone capsule. When the results

presented in Figure 9 are compared to those presented in Figure 7, it can be seen that the microphone having two capacitors in parallel is more sensitive to RF disturbances at the frequency range of 1300 - 1600 MHz. The peak in Figure 9 at these frequencies results from the resonance frequency of the two capacitors in parallel. The sensitivity to disturbances of the third microphone according to the invention may thus be strongly dependent on the RF frequency. A microphone according to the invention thus preferably comprises one capacitor within the microphone capsule.

A standard ETS300-342 specifies another way of testing microphones. For the frequency range of 150 kHz – 80 MHz a standard test method is to inject via a clamp a to the device a voltage of 3 V and to study the effect of the conduction. For frequency range 80 MHz – 1 GHz, an electro-magnetic field having strength of 3 V/m is typically used in testing. According to the standard a microphone should have disturbances less than –35 dB in these tests. Below, the results have been obtained using a voltage of 6V and an electro-magnetic field of 6 V/m, otherwise the measurements are carried out according to the ETS300-342 standard.

Figure 10 presents the results of a test according to the ETS300-342 standard of a conventional headset. The conventional headset has various filtering and ESD protection components related to the microphone. The measured audio level is presented as a function of frequency at the frequency range of 150 kHz – 80 MHz. Figure 10 can be compared with Figure 11, where similar test results are presented for a headset, where the conventional microphone is replaced with a microphone according to the invention. As can be seen, the microphone according to the invention works well at least with the various external filtering and ESD protection components.

Figure 12 presents the test results for a headset, which has the microphone according to the invention but where the filtering and ESD protection components outside the microphone capsule are removed. When Figure 12 is compared to Figure 11, it can be concluded that the good behavior of the headsets, whose test results are presented in Figures 11 and 12 are related to the microphone according to the invention, not to the filtering and ESD protection components outside the microphone capsule. Furthermore, when Figure 12 is compared to Figure 11, the conclusion is that the headset with a microphone according to the invention works better than the headset with the conventional microphone and with the filtering and ESD protection components outside the microphone capsule.

Figure 13 present the test results for the same headset (the headset with a conventional microphone and with the filtering and ESD protection components outside the microphone capsule) as Figure 10, but here the frequency range is 80 MHz – 1 GHz. The test is carried out according to the ETS300-342 standard. Figure 14 present the test results of a headset having a microphone according to the invention. The measured audio level is in Figure 14 below the accepted upper limit, and for most frequencies lower than that presented in Figure 13. Figures 12 and 14 indicate that a microphone according to the invention can pass the tests according to the ETS300-342 standard.

The microphones discussed in this description are electret microphones, but the invention may also be applied to other types of microphones.

CLAIMS

1. A microphone structure comprising within a microphone capsule
- means for converting changes in air pressure to an electrical signal,
- amplifier (T1, FET) for amplifying the electric signal and having two outputs, each output coupled to an output of the microphone capsule, and
- a capacitor (C1, C2, CAP) connected between the outputs of the amplifier, **characterized** in that it further comprises an electro-static discharge protector (R2, VAR) connected between the microphone capsule outputs and, within the microphone capsule, a resistor (R1, RES) coupled in series with the capacitor.

2. A microphone structure according to claim 1, **characterized** in that the electro-static discharge protector is within the microphone capsule.

3. A microphone structure according to claim 2, **characterized** in that the electro-static discharge protector, the resistor, the capacitor and the amplifier are on the same circuit board.

4. A microphone structure according to claim 1, **characterized** in that the electro-static discharge protector is outside the microphone capsule and connected to the microphone capsule outputs near the microphone capsule.

5. A microphone structure according to claim 1, **characterized** in that the electro-static discharge protector is a varistor.

6. A microphone structure according to claim 1, **characterized** in that the capacitance of the electro-static protector is within the range from 10 pF to 10 nF, the resistance of the resistor is within the range from 1 Ω to 1 kΩ and the capacitance of the capacitor is within the range from 10 pF to 5nF.

(57) Abstract

A microphone structure according to the invention comprises within a microphone capsule means for converting changes in air pressure to an electrical signal, amplifier (T1, FET) for amplifying the electric signal and having two outputs, each output coupled to an output of the microphone capsule, and a capacitor (C1, C2, CAP) connected between the outputs of the amplifier. The microphone structure is characterized in that it further comprises an electro-static discharge protector (R2, VAR) connected between the microphone capsule outputs and, within the microphone capsule, a resistor (R1, RES) coupled in series with the capacitor.

Fig. 1

Microphone Capsule, Schematic Diagram

Original WM 63GNT

(Lilly, 10p internal capacitor)

Modified WM 63GNT

(Lilly, 10p internal capacitor)

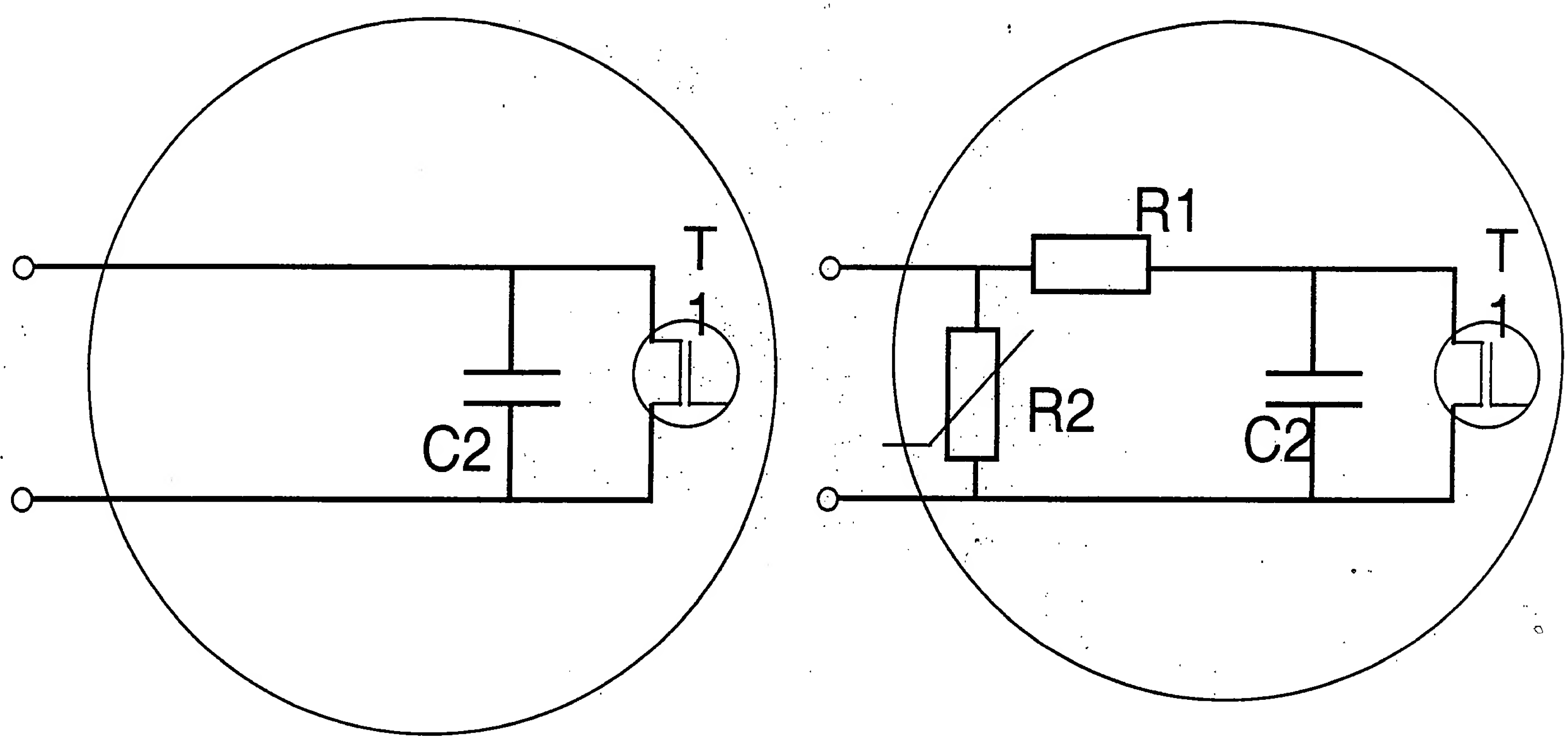
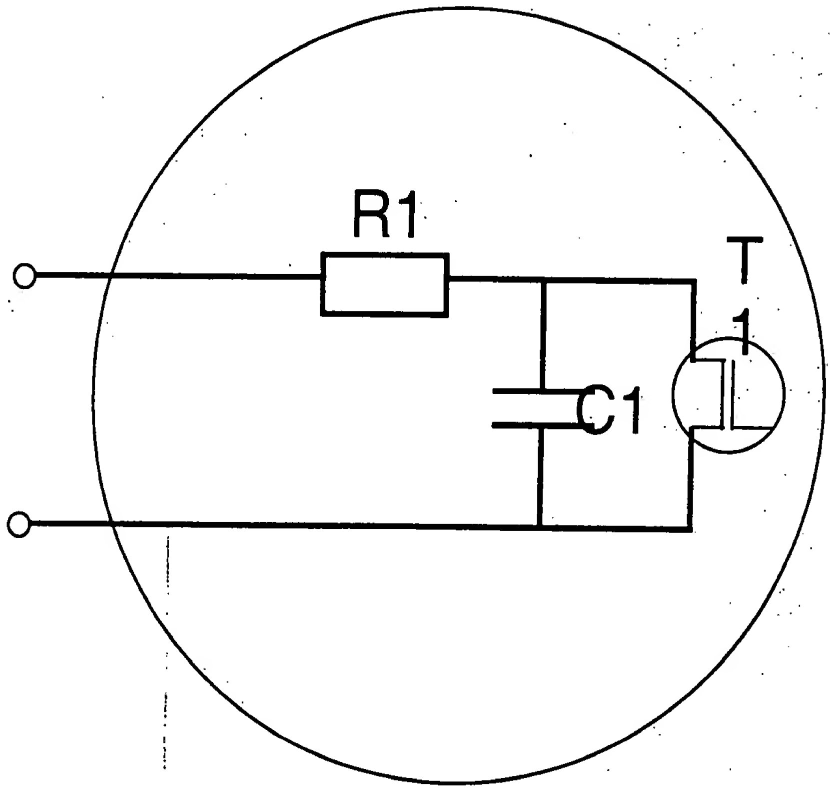


Figure 1

Microphone Capsule, Schematic Diagram

Original KUB3023-018020



Modified KUB3023-018020

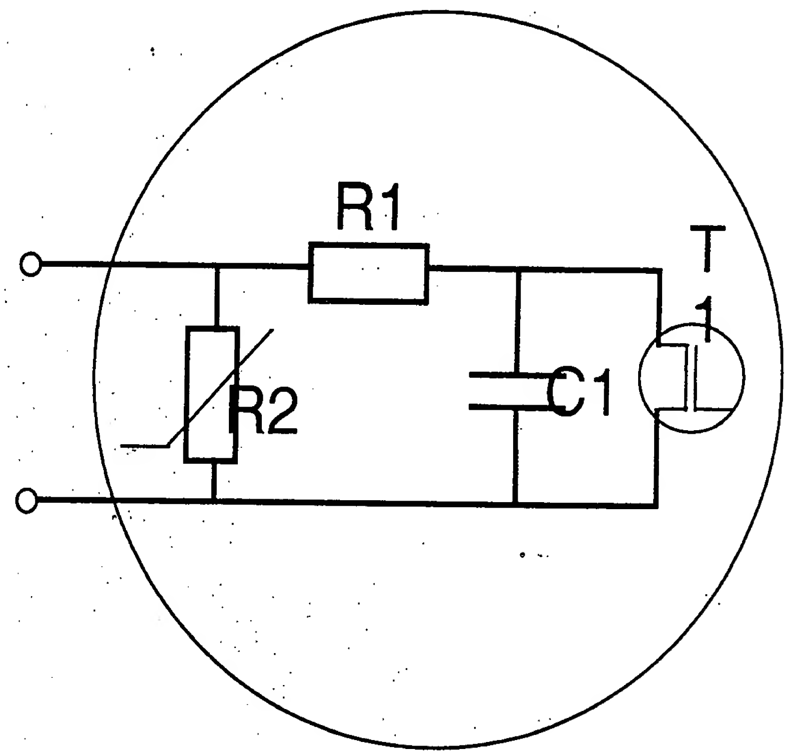


Figure 2

Microphone Capsule, Schematic Diagram

Original WM 63GNT (Lilly) Modified WM 63GNT (Lilly)

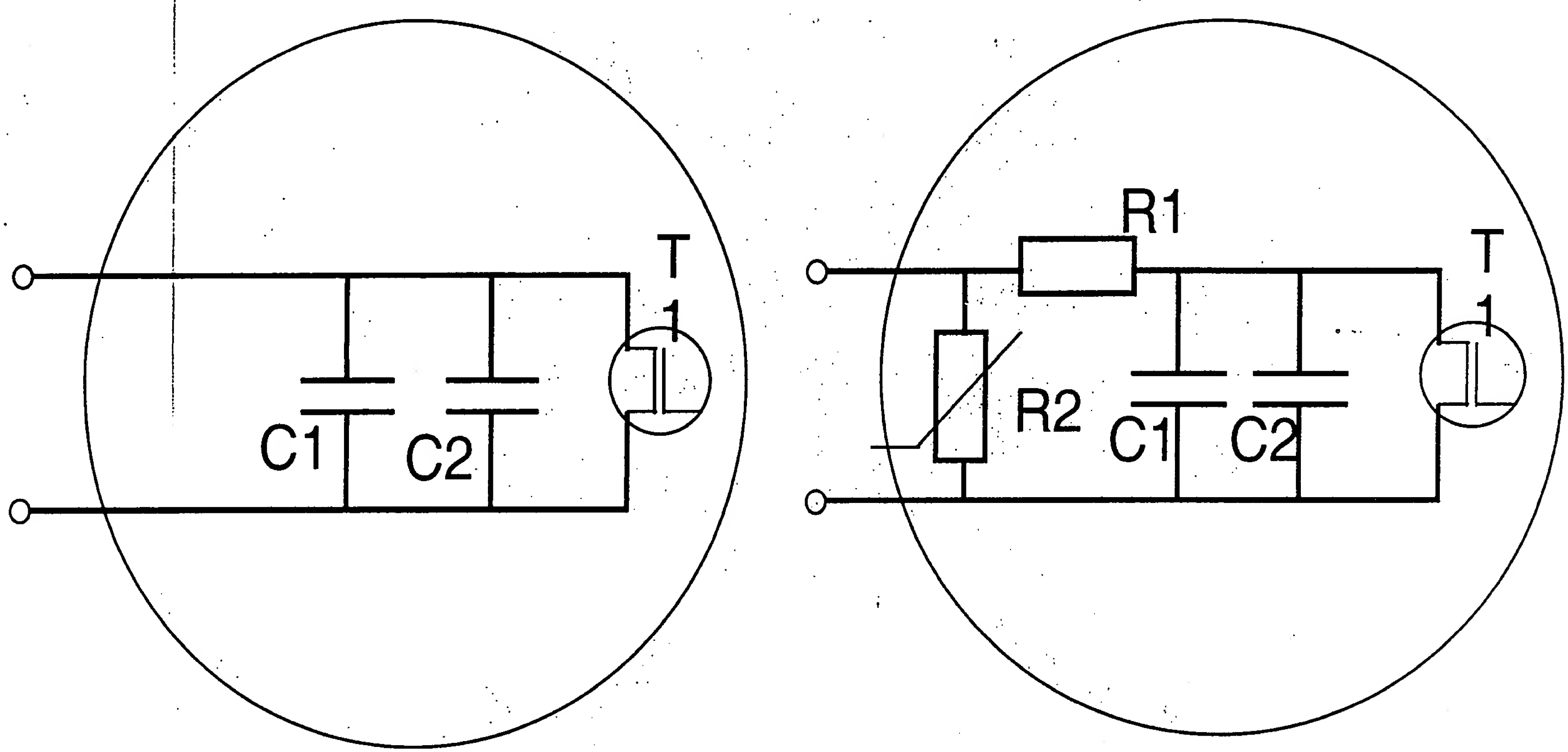


Figure 3

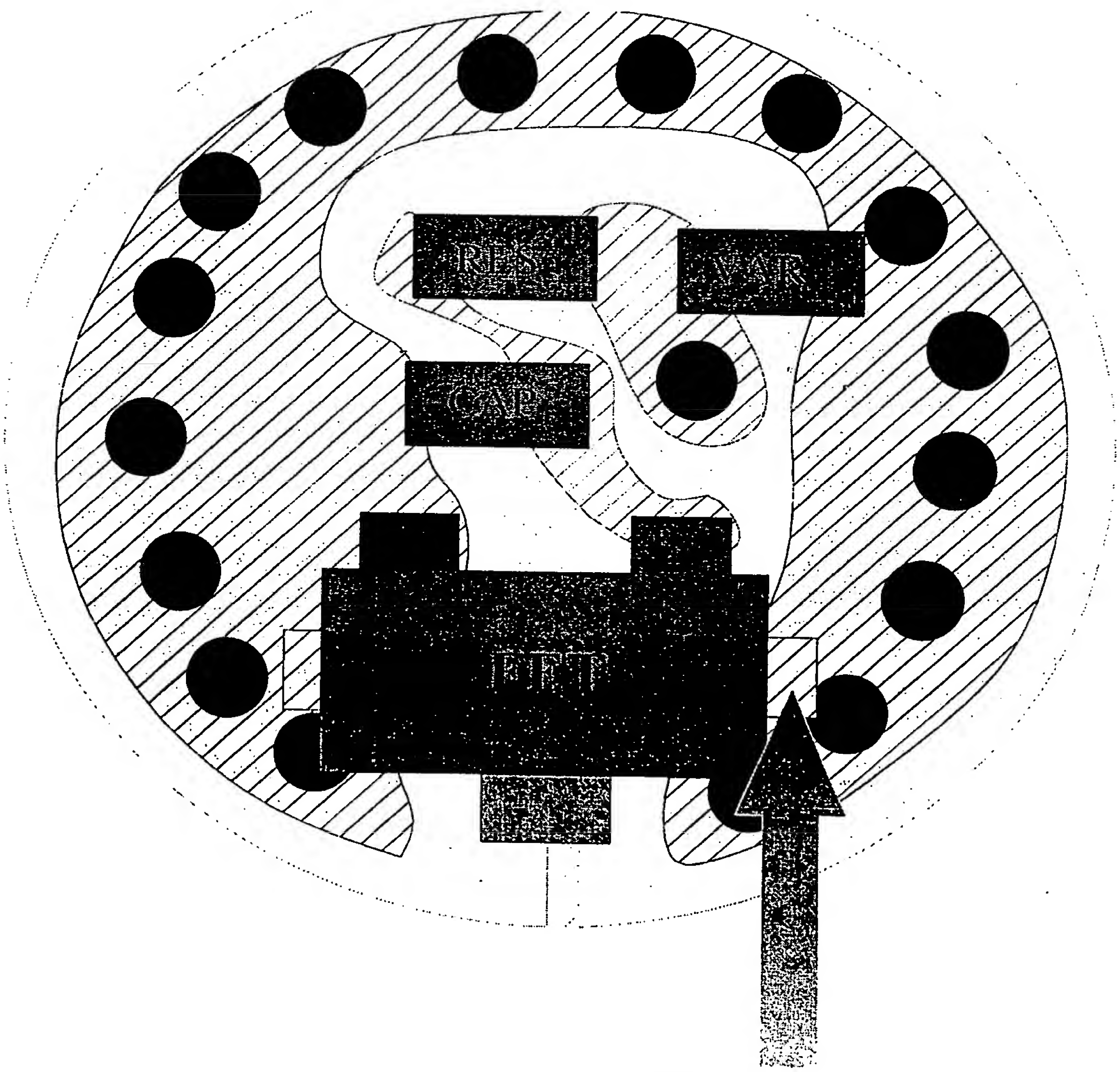


Figure 4

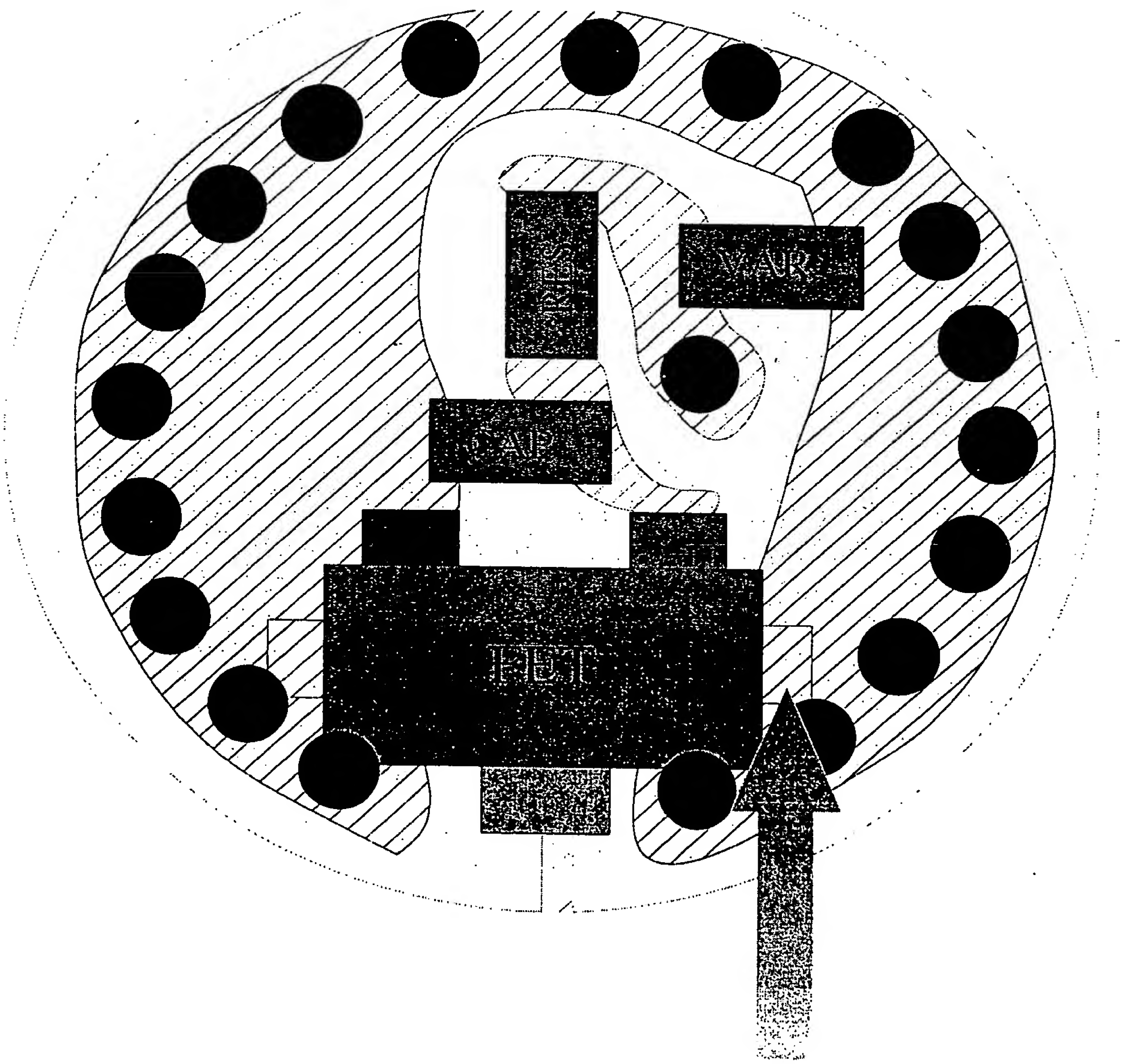


Figure 5

Modular Direct RF Injection

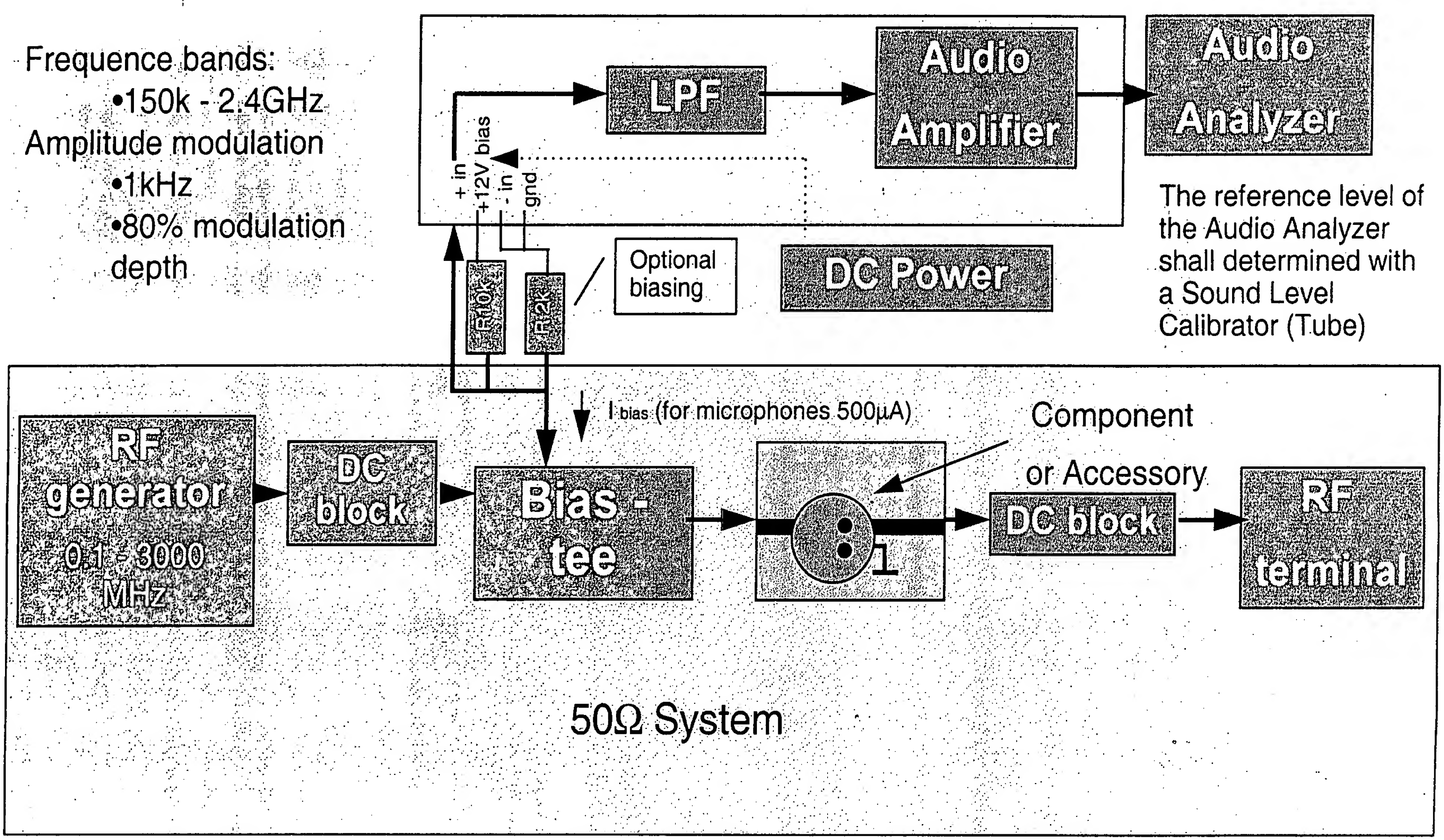


Figure 6

Results, WM63GNT (internal capacitor 10pF)

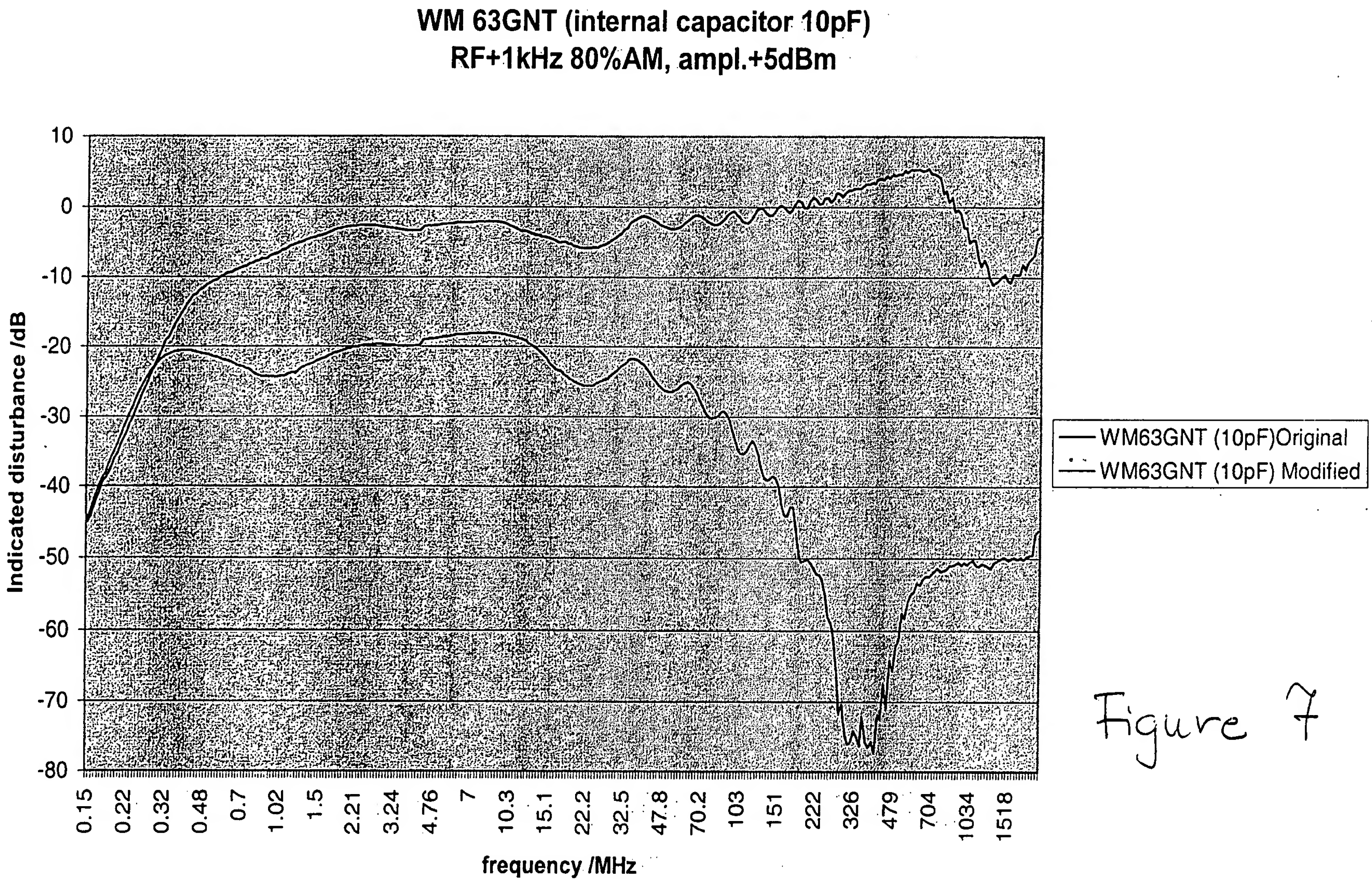


Figure 7

Results, KUB3023-018020

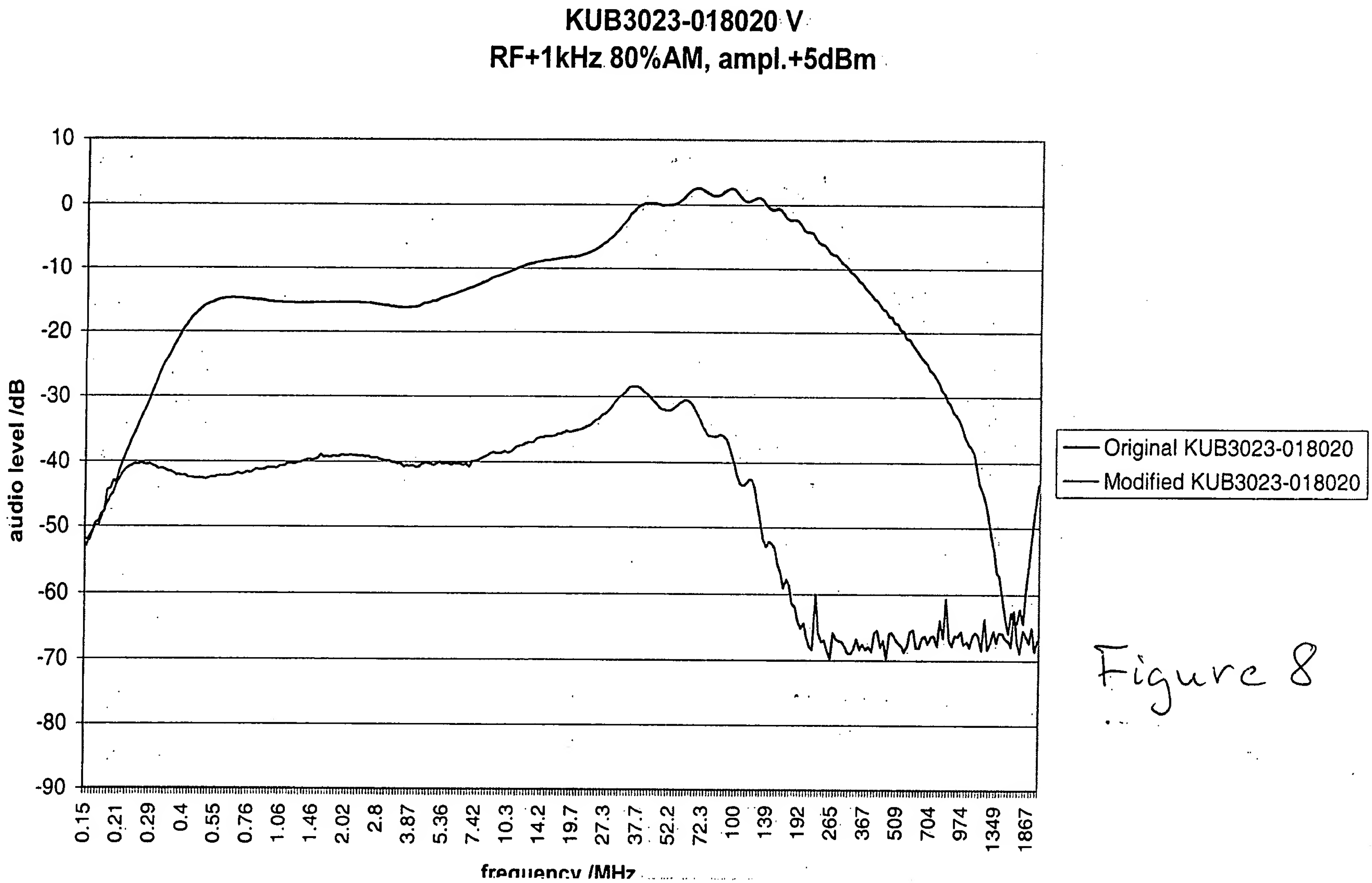


Figure 8

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Results, WM63GNT

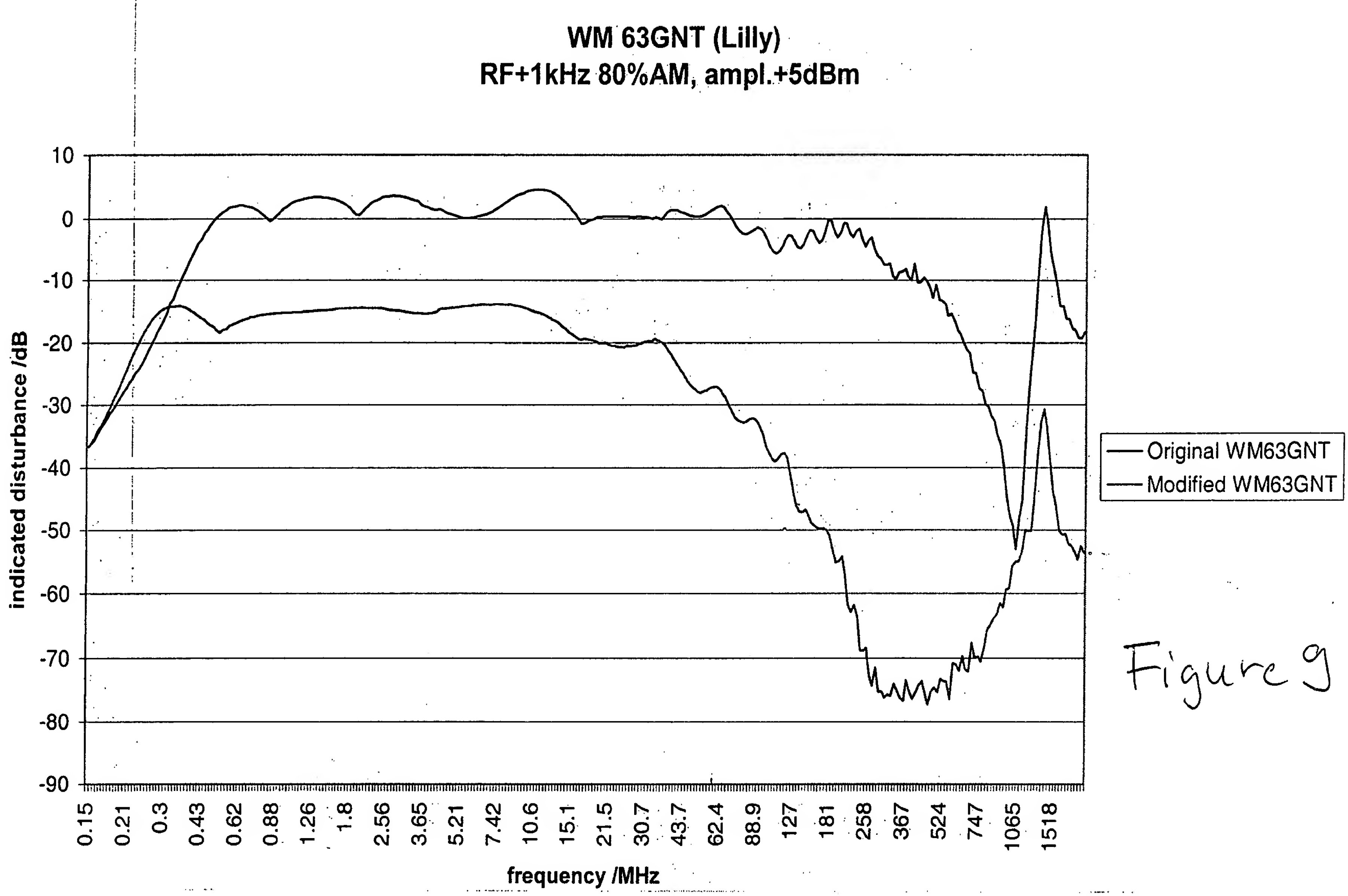

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Figure 9

10/14

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NOKIA MOBILE PHONES SALO

CONDUCTED IMMUNITY TEST REPORT
COMPANY CONFIDENTIAL

1

Equipment under test:	Date & Time
7110, 448895/10/225085/2 ORIGINAL HEADSET HDC-9P	31.1.2000 12:37
Notes: Audiomittausvii ve 0.25sec	
Test Setup Common voltage: 6V (ref plot: None) Frequency range: 0.15 to 80 MHz Freq. steps: all steps Clamp connected to: Charger-cable	
Contact Persons	**Filename**
Tested by Tapio Ronkainen Requested by Nina Muurinen, from project Toolbox	lm000023.xls

Uplink Results

RF	Frq (MHz)	Max (dB)	Mrg (dB)	Result
6V	1,450	-37,2	2,2	NEAR

Downlink Results

RF	Frq (MHz)	Max (dB)	Mrg (dB)	Result
6V	2,500	-111,5	76,5	PASS

RX Quality Result

Worst RXQ during test	Margin	Result
0	3	PASS

Summary	NEAR

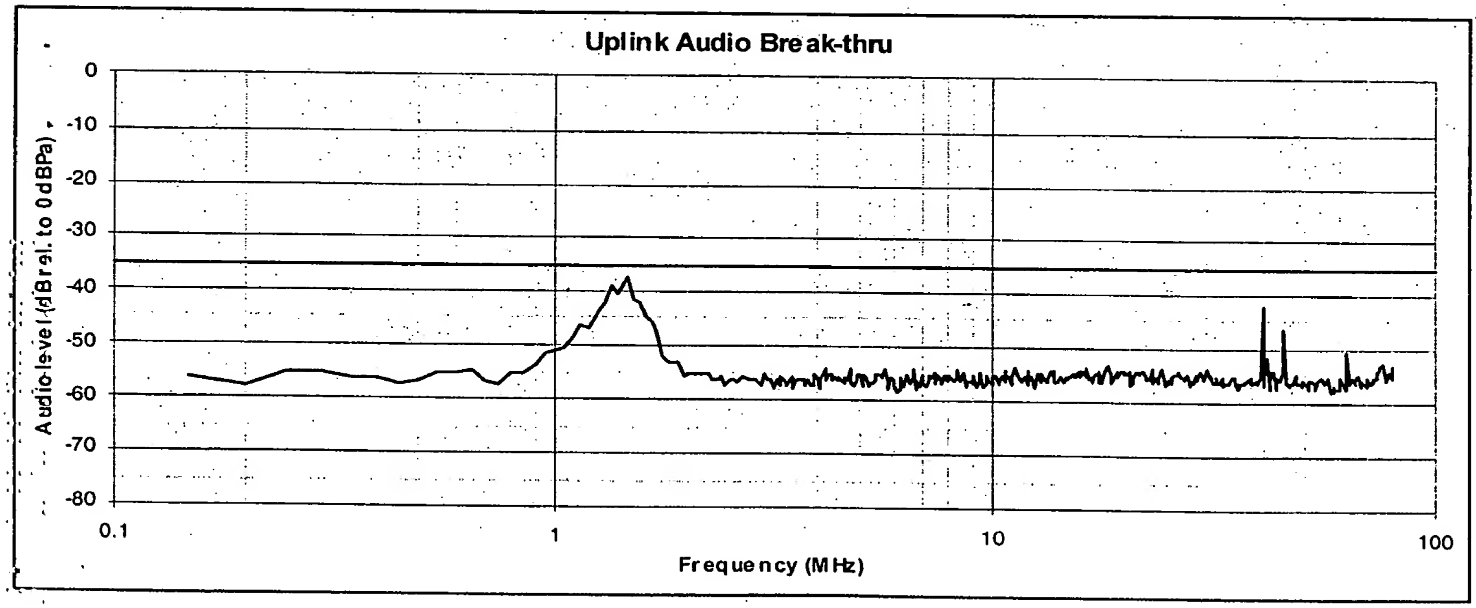

Figure 10

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CONDUCTED IMMUNITY TEST REPORT

NOKIA MOBILE PHONES SALO

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2

Equipment under test:	Date & Time
7110, 448895/10/225085/2 **HDC-9P WITH MICROPHONE HAVING PI-FILTER AND ESD PROTECTION**	1.2.2000 9:33
Notes: Audiomittausviive 2 sec	
Test Setup Common voltage: 6V (ref plot: None) Frequency range: 0.15 to 80 MHz Freq. steps: all steps Clamp connected to: Charger-cable	
Contact Persons	**Filename**
Tested by Tapio Ronkainen	Im000031.xls
Requested by Nina Muurinen, from project Toolbox	

Uplink Results				
RF	Frq (MHz)	Max (dB)	Mrg (dB)	Result
6V	58,975	-54,2	19,2	PASS

Downlink Results				
RF	Frq (MHz)	Max (dB)	Mrg (dB)	Result
6V	2,500	-125,7	90,7	PASS

RX Quality Result		
Worst RXQ during test	Margin	Result
0	3	PASS

Summary	PASS

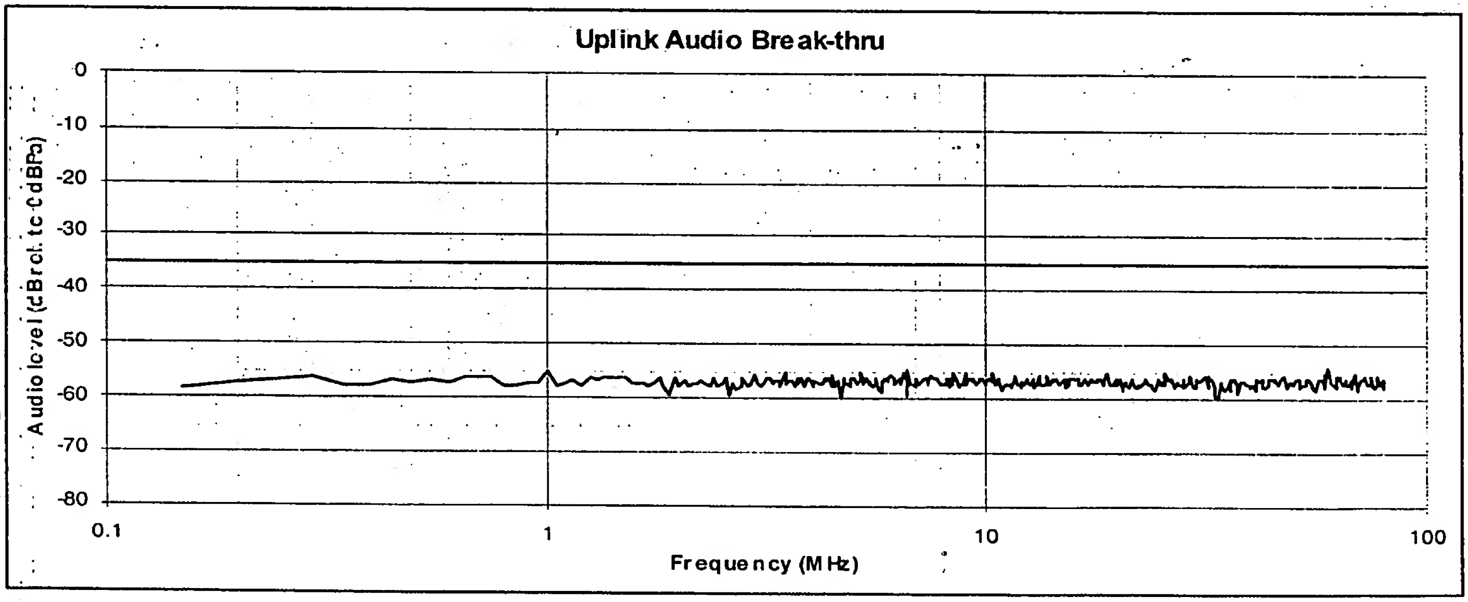

Figure 11

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CONDUCTED IMMUNITY TEST REPORT

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3

Equipment under test:	Date & Time
7110, 448895/10/225085/2 **2 + HEADSET** **PCB** **COMPONENT** **S REMOVED**	1.2.2000 11:21
Notes: Audiomittausvii ve 0.25 sec	
Test Setup Common voltage: 6V (ref plot: None) Frequency range: 0.15 to 80 MHz Freq. steps: all steps Clamp connected to: Charger-cable	
Contact Persons	**Filename**
Tested by Tapio Ronkainen	Im000035.xls
Requested by Nina Muurinen, from project Toolbox	

Uplink Results				
RF	Frq (MHz)	Max (dB)	Mrg (dB)	Result
6V	78,703	-54,3	19,3	PASS
Downlink Results				
RF	Frq (MHz)	Max (dB)	Mrg (dB)	Result
6V	33,447	-116,1	81,1	PASS
RX Quality Result				
Worst RXQ during test			Margin	Result
0			3	PASS
Summary				PASS

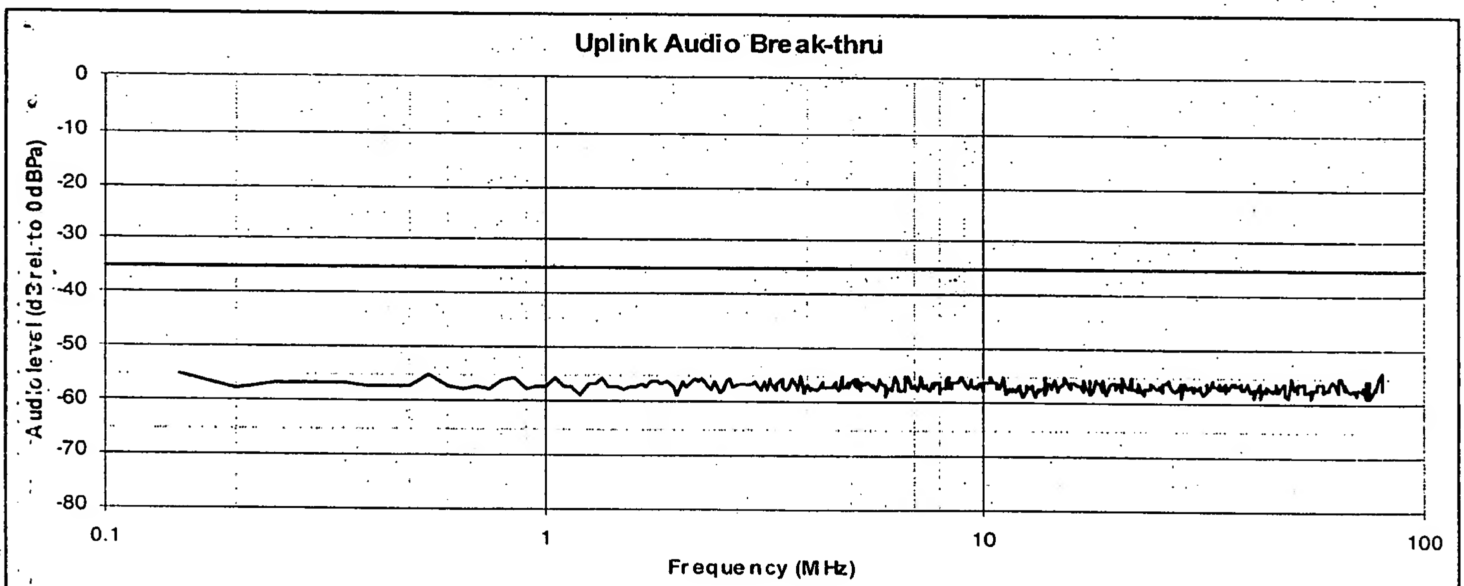

Figure 12

EMC GROUP
NOKIA MOBILE PHONES SALO

RADIATED IMMUNITY TEST REPORT
COMPANY CONFIDENTIAL

1

Equipment under test:	Date & Time
7110, 448895/10/225085/2 ORIGINAL HEADSET HDC-9P	2.2.2000 13:26

Notes:
Audiomittausvii
ve 0.25 sec

Test Setup
RF Field: 6V/m(secondary: None) Field pol: Vertical
Frequency range: 80 to 1000 MHz Freq. steps: all steps
EUT tilt angle: Vertical EUT direction: 90deg.

Contact Persons	Filename
Tested by Tapio Ronkainen	lm000070.xls
Requested by Nina Muurinen, from project Toolbox	

Uplink Results

RF	Frq (MHz)	Max (dB)	Mrg (dB)	Result
6V/m	328,644	-35,9	0,9	NEAR

Downlink Results

RF	Frq (MHz)	Max (dB)	Mrg (dB)	Result
6V/m	99,577	-127,9	92,9	PASS

RX Quality Result

Worst RXQ during test	Margin	Result
0	3	PASS

Summary	NEAR

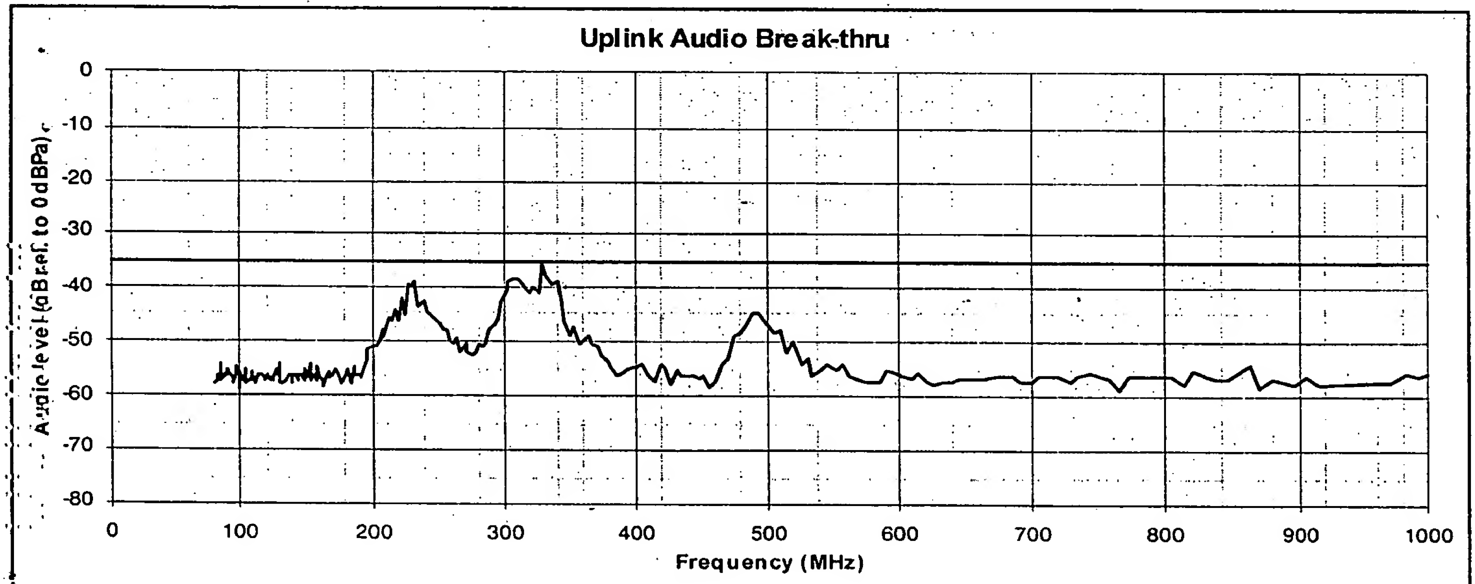

Figure 13

EMC GROUP

NOKIA MOBILE PHONES SALO

RADIATED IMMUNITY TEST REPORT

COMPANY CONFIDENTIAL

2

Equipment under test:	Date & Time
7110, 448895/10/225085/2 HDC-9P WITH MICROPHON E HAVING PI-FILTER AND ESD PROTECTION + HEADSET PCB COMPONENT S REMOVED + HEADSET CONNECTOR PCB REMOVED	2.2.2000 10:39

Notes:
Audiomittausvii
ve 0.25 sec

Test Setup
RF Field: 6V/m(secondary: None) Field pol: Vertical
Frequency range: 80 to 1000 MHz Freq. steps: all steps
EUT tilt angle: Vertical EUT direction: 90deg.

Contact Persons	Filename
Tested by Tapio Ronkainen	Im000066.xls
Requested by Nina Muurinen, from project Toolbox	

Uplink Results

RF	Frq (MHz)	Max (dB)	Mrg (dB)	Result
6V/m	80,000	-36,6	1,6	NEAR

Downlink Results

RF	Frq (MHz)	Max (dB)	Mrg (dB)	Result
6V/m				

RX Quality Result

Worst RXQ during test	Margin	Result
0	3	PASS

Summary	NEAR

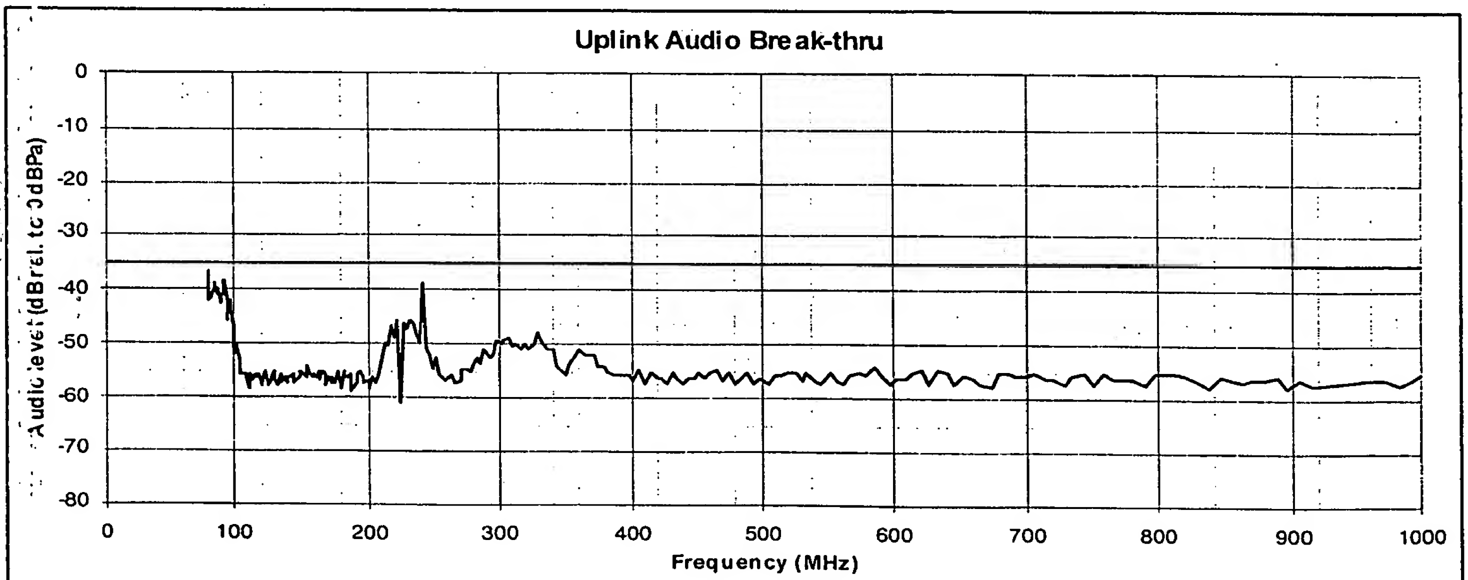

Figure 14